Mechanisms for Exchange of Image Data to Support Distant Medical Consultation

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Abstract

The VA has developed an integrated infrastructure to support the exchange of medical data, including images and text report data, between medical centers. This capability is expected to support teleconsulting and meet a variety of existing medical staffing and consultation needs. Consultation from distant locations requires at least the same complete integrated patient record available to onsite physicians. Several mechanisms are being explored to support distant medical consultation. Multimedia extensions to the VA's electronic mail system have been developed to allow images and other data objects to be included in electronic mail messages. Another approach that has been prototyped is to extend existing local imaging networks to produce more widely distributed imaging systems. These approaches will be described and discussed.

THE VETERANS HEALTH CARE INFORMATION SYSTEMS

The VA has developed an integrated infrastructure to support the exchange of medical data. This includes computer hardware, software development tools, compatible hospital information systems, and a full featured electronic mail system, with a wide area network connecting its sites to support the exchange of medical data. This infrastructure allows the development of a variety of modes of data exchange to suit the range of medical needs within the VA facilities.

Part of this infrastructure is the VA's hospital information system (HIS), the Decentralized Hospital Computer Program (DHCP). This HIS has recently been extended to create a powerful distributed local area network system to integrate image, text and other types of medical data[1,2]. The network includes magnetic and optical image servers, hospital information system servers, and imaging workstations located throughout the hospital. This system captures and displays a wide variety of medical images, including cardiology, bronchoscopy, gastrointestinal endoscopy, hematology, surgical pathology, surgery, dermatology, ophthalmology, vascular, and radiology images. The goal of the VA's DHCP Imaging System is to provide image and text data in an integrated manner that facilitates the clinician's making of patient care decisions in a timely and accurate way. This system is oriented toward providing the treating physician with a complete view of patient data, at the same time allowing consulting physicians to have access to the full range of data [3].

The VA is developing and testing the ability to transmit images and associated text data between VA medical centers. This capability is expected to meet a variety of existing medical staffing and consultation needs. It would allow consulting physicians at a distant VA location to assist physicians at any VAMC. Sites where one or two physicians must cover night and weekend call schedules could use teleconsultation to reach oncall physicians at their residences, allowing staff to provide rapid response at lower cost. VA's often send patients to other sites for special procedures; transmission of the resulting report including images would assist physicians at the referring site. Image transmission also offers a promising extension to the VA's quality control procedures.

Several issues are important when transmitting patient records. Consultation from a distant location requires at least the same complete integrated patient record available to onsite physicians. Both images and associated text must be transmitted and their association must be maintained. Commercial teleconsulting systems typically are unable to provide this. The VA's software infrastructure includes integration structures at each medical center to support this capability. Another important issue is the time

0195-4210/92/$5.00

and resources required to transmit images which are particularly large files. Finally, security and privacy of patient data is critical.

Several mechanisms are being explored to support distant medical consultation. Multi-media extensions to the VA's electronic mail system have been developed to allow images and other data objects to be included in mail messages sent between sites. Another approach that has been prototyped is to extend existing local imaging networks to produce more widely distributed imaging systems. These approaches will be discussed below.

THE VA'S NATIONAL NETWORK

Nationwide Packet-switched Network

To connect its over 600 major facilities, the VA has installed a wide area packet-switched network known as the Integrated Data Communications Utility (IDCU) which is commercially supported. It consists of 23,000 miles of fully digital optical fiber network and handles a number of protocols including asynchronous and X.25. Sites typically communicate at 4,800 or 9,600 baud rates, although it is possible to achieve rates up to 56,000 baud using X.25 or direct lines.

ISDN

The VA has installed integrated services digital network (ISDN) lines at the Washington DC VA Medical Center, the Baltimore MD VA Medical Center and the Washington Information Systems Center. All three locations have imaging systems. In collaboration with the National Institute for Standards and Technology, this network was used to demonstrate a widely distributed DHCP Imaging System during the "golden spike" splicing of the nationwide ISDN network in November 1992. These lines are basic rate ISDN lines, transmitting data at 112 kb/s. ISDN technology is a possible solution to the goals of the Clinton/Gore administration's information superhighway initiative [4].

Frame Relay Communications

Pilot testing of frame relay with effective rates up to 1 mb/second is currently in progress between three VA imaging sites. This provides faster communication than the other networks, but uses the same exchange mechanisms as IDCU.

MECHANISMS FOR EXCHANGE OF IMAGE AND TEXT DATA

Three mechanisms which have been examined for transmission of integrated image and text data outside the local area network will be discussed below:

(1) Use of multimedia electronic mail software for communication of text and images between sites

(2) Use of a wide area distributed system through a virtual extension of Ethernet

(3) Use of a protocol such as the VA's Patient Data Exchange (PDX), ACR-NEMA, or HL7 protocol that allow text and image data to be requested and sent between systems

MULTIMEDIA ELECTRONIC MAIL SOFTWARE

One of the components of the VA's hospital information system software is an electronic mail package called Mailman which provides both local and network distribution of messages, programs, file structures, and patient or other data. Mailman runs at all VA medical centers and can be used to move data between HIS systems at different sites. This facility has been used to create consolidated patient registries, to move patient data during emergencies, and by the Indian Health Service to synchronize patient records across several treatment sites. Because patient data can be added to existing records, it allows the maintenance of an integrated patient record. In addition, any DHCP report can be directed to a mail message that can be sent to any user nationwide. Mailman complies with the Internet mail standard Simple Mail Transfer Protocol (SMTP).

Enhancements are currently being alpha-tested to allow transmission of other data objects, such as images or electrocardiograms, as an integral part of a mail message. These objects are managed by the same object file structures used by the DHCP Imaging System described elsewhere [6,7,8]. A mail message may contain pointers to data objects as one of its body parts. These structures will allow the integration of the data contained in the

mail message with the patient's online record at the receiving site.

Each test site operates a local area imaging network as described above (see Figure 1). The LAN at each test site includes (a) image servers running Novell Netware for image access from workstations and Netware NFS for image access from DHCP HIS; (b) DHCP servers which operate ASCII terminals and provide text data to workstations; these run Wollongong NFS for image access; (c) imaging workstations for capture and display of images and text. Wide area communications (Comm) may use 9600 baud IDCU connections, 56 kb/s line, frame relay or any other mechanism that supports TCP/IP. When a multimedia message is sent, the receiving system is queried in the background for its image server address and directory information. The necessary commands to send the associated multimedia data object to the receiving network node via TCP/IP File Transfer Protocol (FTP) are automatically generated and executed. The routing to control the communications pathway is independent of the applications software, allowing switching to slower communications pathways in case of failure.

An imaging workstation at the receiving facility displays the images simultaneously with the textual message information. In order to conserve network resources, the mailman software performs checks before sending a data object to determine if the receiving site already has the data object as part of a previous message.

WIDE AREA DISTRIBUTED SYSTEM

This approach uses a widely distributed system where remote imaging workstations have access across a virtual extension of the Ethernet to remote servers. They run the same software and behave the same as a local workstation. This can be done simply through virtual extension of the Ethernet using switched or permanent data circuits at rates of 14.4 kilobits/second (telephone modems) or 112 kb/s (ISDN). This mechanism has been used to provide remote support of the imaging systems at the medical centers. It provides the advantage that no software changes are needed; this is ideal for field support. It allows ad hoc query and the use of our standard image abstract menus for user selection of image data to be viewed. Security issues are more difficult than with the above mechanism, as the entire computer industry is discovering.

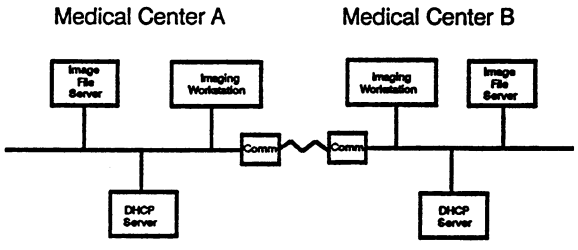

Figure 1: Wide Area Network Connecting Two Medical Centers

PROTOCOL FOR REQUESTING AND SENDING TEXT AND IMAGE DATA

This approach uses of a protocol such as ACR-NEMA or PDX consisting of a request message asking for data to be sent and a reply message containing the data. This mechanism is well suited for transmission to non-VA institutions that do not run Mailman or to small portable VA systems outside the VA medical centers. This mechanism provides good security by allowing control of the data flow by the requesting and sending systems with security checking before release of data. The two-way protocol enhances reliability.

The VA's Patient Data Exchange (PDX) software module is designed to allow medical centers to request and receive data including demographics, episodes of care, medication, and diagnostic evaluations from other medical centers. This information can then be integrated into a coherent composite record at the receiving site, enhancing the quality of care provided for the patient.

PDX has three modes of operation. In its first mode, it provides for the creation of hospital groups which exchange data relatively freely. When data is requested by staff at a hospital that is a group member, the data is automatically returned with no human interaction at the sending site. PDX uses Mailman to deliver the data within 12 minutes of the request entry. The reply is returned as a mail message that can be displayed on the screen, printed, or the data can be uploaded into the local DHCP system. In the second mode, the requesting hospital is not a workgroup member. In this case, the remote site will be sent a bulletin requiring human interaction

by the information officer to allow the information to be provided. In the third mode, an unsolicited transmission may be sent by a site to another, as when a patient transfer occurs. In any mode, all requests are recorded, patient identification is required, and patient data is only sent to medical centers. When a facility has designated a particular patient's records as sensitive, these can only be transmitted by an authorized user. In the future, the PDX facility will be supporting the HL7 message structure and will allow the transfer of clinical record data from the Health Summary package. PDX is compatible with the multimedia capability described above and will be extended for use with this new capability.

DISCUSSION

Three mechanisms of medical data exchange have been described in this article, each having its own benefits. These use two underlying mechanisms for exchange of data: electronic mail extensions and wide distribution of the network. The selection of a data exchange method for a particular application depends on a number of factors, including the need for rapid user interaction with the data; the need to perform ad hoc data queries; whether user access to a predefined set of data is adequate; whether the user requires simple or transparent access to data; whether there is a need for an integrated view of data located at more than one site; the amount and sensitivity of the data to be transferred.

Transmission of Integrated Patient Data

Images are an integral part of a patient's clinical data. Physicians typically insist on viewing images before making treatment decisions. When a physician provides a consultation from a remote site, he or she is limited in their examination of the patient. This is understood by the treating physicians who make the ultimate decisions. To render the best advice, the distant physician should be provided with at least the same complete integrated patient record that is available to onsite physicians. This means that both images and associated text must be transmitted and their association must be maintained. Commercial teleconsulting systems typically provide only images with minimal identifying information. All of the VA's considered approaches to data exchange support the transmission of complete integrated patient data.

Multimedia mailman electronic mail appears to be an excellent tool for some types of medical teleconsultation as it can transmit reports from any HIS module with associated images, and security is built in. TCP/IP is used to transmit the image data using a variety of network configurations between VA medical centers. A consultation request and reply is analogous to an elecronic message exchange. The sender controls the data flow, and can determine the data that the recipient needs to have. A record of the request and data sent is created. Mailman provides the capability to forward mail to another individual for additional consultation. Other VA software tools provide the ability to integrate data received with the database at the remote site. Limitations include the inability to perform ad hoc queries and the requirement to develop software modifications to support this kind of transfer.

The distributed system approach allows the use of remote systems as though the user were local. The user's access privileges are verified, and the user is allowed to browse among data just as on site users may. Security must be provided by mechanisms such as physical security devices on secured workstations and caller-id verification. This approach reduces user training needs and improves their ability to locate the required data because the customary user options are employed.

Image Transmission Rates

Transmission of image data consumes network resources and can be a lengthy procedure (see Table I). Faster communication lines can be used to reduce transmission time, but costs may increase. Image compression techniques can be used to reduce image file sizes. However, care must be taken to avoid degradation of image quality, a feature which is often difficult to assess. Applications software and high level protocols require time beyond that of a simple file transfer. Initial tests with Multimedia Mailman showed transmission of a text message with one image required just under 15 minutes over IDCU and less that 30 seconds over Frame Relay.

Security

The VA is covered by the Privacy Act for its distribution of data between government centers. Special issues will be posed by transfers outside of facilities not covered by the Act, such as private

Table I: Image Transmission Rates (single concurrent file transfers)

Telecommunication Technology	Time Required to Transmit 0.75 mb Image File
IDCU X.25 (9600 baud)	11 minutes (FTP GET, VAX-to-VAX)
Modem with MNP (14.4 kbaud)	7 minutes (Novell READ, 386-to-486)
ISDN Basic Rate (112 kb/s)	1 minute (Novell READ, 386-to-486)
Frame Relay (1 mb/s)	7-12 seconds (FTP GET, VAX-to-VAX)

hospitals. Within the VA, data exchange relies on compliance of systems with the VA's Privacy Act protocols.

The use of a request-reply message protocol allows the system to check security privileges and then supply predefined data to the remote system. The remote system can then provide integration with its own database if this is desirable.

CONCLUSIONS

Exchange of medical data between distant medical centers has the potential to be extremely useful in providing healthcare. Consultation from a distant location requires at least the same complete integrated patient record available to onsite physicians. This means that both images and associated text must be transmitted and their association must be maintained. This requires an infrastructure including systems, network and software tools.

There are many approaches to providing remote data exchange. Selection of a data exchange approach to meet particular needs requires balancing of various factors, including the need for rapid interactive access to data and ad hoc queries, the adequacy of access to predefined data sets, the need for an integrated view of the data, the ability to provide adequate security protection, the amount of data required, and the time frame in which data is required.

The prototypes described here demonstrate ways that the VA can utilize its infrastructure, information standards, and compatible integrated hospital information systems located at its facilities to improve healthcare and the technology supporting distant consultation. The needs that are targeted by the VA are also needs of private hospitals. In many cases, private hospitals do not have the infrastructure in place to allow data exchange. The Clinton/Gore administration is working to provide such an information superhighway nationwide that may open the doors to the kind of technology described here. Such technology may help meet the public's expectations for national healthcare. The VA's experiences may serve to establish the benefits that could be obtained by all hospitals.

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